

Discreteness effects in left-handed metamaterials

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We present the study of a novel physics of composite left-handed metamaterials induced by interaction between the split-ring resonators (SRRs). We consider an example of the cubic lattice of parallel SRRs and study its linear and nonlinear properties. We demonstrate that the effective coupling between the resonators is highly anisotropic, and we derive the discrete coupled-mode equations for describing the propagation of magnetization waves. We show the existence of linear waves of magnetization, and also demonstrate that, in the nonlinear regime, magnetic response of a nonlinear metamaterial may become bistable, and we analyze modulational instability of different nonlinear states. We predict that nonlinear metamaterials may support the propagation of domain walls (kinks) connecting the regions of different states of magnetization, and study their dynamics. Two out-of-phase kinks may create a magnetization domain; a possibility to control the dynamics of such domains is promising for a design of the structures with controllable magnetization and photonic crystals which parameters can be made tunable.

[1] I.V. Shadrivov, A.A. Zharov, N.A. Zharova, and Yu.S. Kivshar, arxiv:cond-mat/0501653